

CLAIMS

What is claimed is:

- 1 1. An apparatus that provides a radio frequency energy to a probe placed in contact with a cornea to perform a medical procedure, comprising:
  - 4 a radio frequency circuit that delivers a radio frequency energy to the cornea through the probe; and,
  - 6 a regulator circuit that controls the radio frequency energy delivered to the cornea during the medical procedure.
- 1 2. The apparatus of claim 1, further comprising a sensing circuit that senses a change in a physiology of the cornea during the medical procedure and provides a feedback to said regulator circuit.
- 1 3. The apparatus of claim 2, wherein said sensing circuit senses a current delivered to the cornea.

1       4. The apparatus of claim 2, wherein said sensing  
2 circuit senses a voltage delivered to the cornea.

1       5. The apparatus of claim 2, wherein said sensing  
2 circuit senses a temperature of the cornea.

1       6. The apparatus of claim 2, wherein said sensing  
2 circuit senses an impedance of the cornea.

1       7. The apparatus of claim 2, wherein said sensing  
2 circuit senses a moisture of the cornea.

1       8. The apparatus of claim 1, wherein said regulator  
2 circuit controls the delivery of the radio frequency energy  
3 about a set-point.

1       9. The apparatus of claim 1, wherein said regulator  
2 circuit controls the delivery of the radio frequency energy  
3 about a set-curve.

1       10. The apparatus of claim 2, wherein said regulator  
2 circuit determines a profile of a physiological parameter

3 and regulates the radio frequency energy delivered to the  
4 cornea in accordance with the profile.

1 11. The apparatus of claim 10, wherein the profile is  
2 an impedance profile.

1 12. The apparatus of claim 10, wherein the profile is  
2 a temperature profile.

1 13. The apparatus of claim 10, wherein the profile is  
2 a moisture profile.

1 14. The apparatus of claim 10, wherein said regulator  
2 circuit decreases the radio frequency energy if the profile  
3 includes an increase in impedance beyond a threshold level  
4 during the medical procedure.

1 15. The apparatus of claim 10, wherein said regulator  
2 circuit terminates delivery of the radio frequency energy  
3 if the profile exceeds a threshold level during the medical  
4 procedure.

1       16. The apparatus of claim 10, wherein said regulator  
2 circuit terminates delivery of the radio frequency energy  
3 if the profile includes a slope that exceeds a threshold  
4 level during the medical procedure.

1       17. The apparatus of claim 16, wherein said regulator  
2 circuit modulates a duration of the delivery of the radio  
3 frequency energy.

1       18. The apparatus of claim 17, wherein said duration  
2 is modulated in response to changes in a profile of the  
3 physiological parameter.

1       19. The apparatus of claim 18, wherein the  
2 physiological parameter is an impedance.

1       20. The apparatus of claim 18, wherein the  
2 physiological parameter is a temperature.

1       21. The apparatus of claim 18, wherein the  
2 physiological parameter is a tissue moisture.

1       22. The apparatus of claim 1, wherein said regulator  
2 circuit modulates a level of the radio frequency energy.

1       23. An apparatus that provides a radio frequency  
2 energy to a probe placed in contact with a cornea to  
3 perform a medical procedure, comprising:

4       a radio frequency circuit that delivers a radio  
5 frequency energy to the cornea through the probe; and,  
6       regulator circuit means for controlling the radio  
7 frequency energy delivered to cornea during the medical  
8 procedure.

1       24. The apparatus of claim 23, further comprising  
2 sensing circuit means for sensing a change in a physiology  
3 of the cornea during the medical procedure and providing a  
4 feedback to said regulator circuit.

1       25. The apparatus of claim 24, wherein said sensing  
2 circuit means senses a current delivered to the cornea.

1        26. The apparatus of claim 24, wherein said sensing  
2    circuit means senses a voltage delivered to the cornea.

1        27. The apparatus of claim 24, wherein said sensing  
2    circuit means senses a temperature of the cornea.

1        28. The apparatus of claim 24, wherein said sensing  
2    circuit means senses an impedance of the cornea.

1        29. The apparatus of claim 24, wherein said sensing  
2    circuit means senses a moisture of the cornea.

1        30. The apparatus of claim 23, wherein said regulator  
2    circuit means controls the delivery of the radio frequency  
3    energy about a set-point.

1        31. The apparatus of claim 23, wherein said regulator  
2    circuit means controls the delivery of the radio frequency  
3    energy about a set-curve.

1        32. The apparatus of claim 24, wherein said regulator  
2    circuit means determines a profile of a physiological

3 parameter and regulates the radio frequency energy  
4 delivered to the cornea in accordance with the profile.

1 33. The apparatus of claim 32, wherein the profile is  
2 an impedance profile.

1 34. The apparatus of claim 32, wherein the profile is  
2 a temperature profile.

1 35. The apparatus of claim 32, wherein the profile is  
2 a moisture profile.

1 36. The apparatus of claim 32, wherein said regulator  
2 circuit means decreases the radio frequency energy if the  
3 profile includes an increase in impedance beyond a  
4 threshold level during the medical procedure.

1 37. The apparatus of claim 32, wherein said regulator  
2 circuit means terminates delivery of the radio frequency  
3 energy if the profile exceeds a threshold level during the  
4 medical procedure.

1       38. The apparatus of claim 32, wherein said regulator  
2 circuit means terminates delivery of the radio frequency  
3 energy if the profile includes a slope that exceeds a  
4 threshold level during the medical procedure.

1       39. The apparatus of claim 23, wherein said regulator  
2 circuit means modulates a duration of the delivery of the  
3 radio frequency energy.

1       40. The apparatus of claim 39, wherein said duration  
2 is modulated in response to changes in a profile of the  
3 physiological parameter.

1       41. The apparatus of claim 40, wherein the  
2 physiological parameter is an impedance.

1       42. The apparatus of claim 40, wherein the  
2 physiological parameter is a temperature.

1       43. The apparatus of claim 40, wherein the  
2 physiological parameter is a tissue moisture.

1       44. The apparatus of claim 23, wherein said regulator  
2 circuit means modulates a level of the radio frequency  
3 energy.

1       45. A method for performing a medical procedure on a  
2 cornea, comprising:  
3       placing a probe in contact with a cornea;  
4       delivering a radio frequency energy to the cornea  
5 through the probe; and,  
6       regulating the radio frequency energy delivered to  
7 cornea during the medical procedure.

1       46. The method of claim 45, further comprising sensing  
2 and feeding back a change in a physiology of the cornea  
3 during the medical procedure and regulating the radio  
4 frequency energy delivered to the cornea as a function of  
5 the feedback.

1       47. The method of claim 46, wherein a current  
2 delivered to the cornea is sensed during the medical  
3 procedure.

1       48. The method of claim 46, wherein a voltage  
2 delivered to the cornea is sensed during the medical  
3 procedure.

1       49. The method of claim 46, wherein a temperature of  
2 the cornea is sensed during the medical procedure.

1       50. The method of claim 46, wherein an impedance of  
2 the cornea is sensed during the medical procedure.

1       51. The method of claim 46, wherein said a moisture of  
2 the cornea is sensed during the medical procedure.

1       52. The method of claim 45, wherein the radio  
2 frequency energy is regulated about a set-point.

1       53. The method of claim 45, wherein the radio  
2 frequency energy is regulated about a set-curve.

1       54. The method of claim 46, wherein a profile of a  
2 physiological parameter is determined and the radio

3 frequency energy delivered to the cornea is regulated in  
4 accordance with the profile.

1 55. The method of claim 54, wherein the profile is an  
2 impedance profile.

1 56. The method of claim 54, wherein the profile is a  
2 temperature profile.

1 57. The method of claim 54, wherein the profile is a  
2 moisture profile.

1 58. The method of claim 54, wherein regulating  
2 includes decreasing the radio frequency energy if the  
3 profile includes an increase in impedance beyond a  
4 threshold level during the medical procedure.

1 59. The method of claim 54, wherein regulating  
2 includes terminating delivery of the radio frequency energy  
3 if the profile exceeds a threshold level during the medical  
4 procedure.

1       60. The method of claim 54, wherein regulating  
2 includes terminating delivery of the radio frequency energy  
3 if the profile includes a slope that exceeds a threshold  
4 level during the medical procedure.

1       61. The method of claim 45, wherein regulating  
2 includes modulating a duration of the delivery of the radio  
3 frequency energy.

1       62. The method of claim 61, wherein the duration is  
2 modulated in response to changes in a profile of the  
3 physiological parameter.

1       63. The method of claim 61, wherein the physiological  
2 parameter is an impedance.

1       64. The method of claim 61, wherein the physiological  
2 parameter is a temperature.

1       65. The method of claim 61, wherein the physiological  
2 parameter is a tissue moisture.

1       66. The method of claim 45, wherein regulating  
2 includes modulating a level of the radio frequency energy.

1       67. An apparatus that provides a radio frequency  
2 energy to a probe placed in contact with a cornea to  
3 perform a medical procedure, comprising:  
4       a radio frequency circuit that delivers a radio  
5 frequency energy to the cornea through the probe; and,  
6       a sensing circuit that senses a change in a physiology  
7 of the cornea while said radio frequency circuit delivers  
8 the radio frequency energy to the cornea.

1       68. The apparatus of claim 67, wherein said sensing  
2 circuit senses a current delivered to the cornea.

1       69. The apparatus of claim 67, wherein said sensing  
2 circuit senses a voltage delivered to the cornea.

1       70. The apparatus of claim 67, wherein said sensing  
2 circuit senses a temperature of the cornea.

1       71. The apparatus of claim 67, wherein said sensing  
2 circuit senses an impedance of the cornea.

1       72. The apparatus of claim 67, wherein said sensing  
2 circuit senses a moisture of the cornea.

1       73. An apparatus that provides a radio frequency  
2 energy to a probe placed in contact with a cornea to  
3 perform a medical procedure, comprising:  
4           a radio frequency circuit that delivers a radio  
5 frequency energy to the cornea through the probe; and,  
6           sensing means for sensing a change in a physiology of  
7 the cornea while said radio frequency circuit delivers the  
8 radio frequency energy delivered to the cornea.

1       74. The apparatus of claim 73, wherein said sensing  
2 means senses a current delivered to the cornea.

1       75. The apparatus of claim 73, wherein said sensing  
2 means senses a voltage delivered to the cornea.

1        76. The apparatus of claim 73, wherein said sensing  
2 means senses a temperature of the cornea.

1        77. The apparatus of claim 73, wherein said sensing  
2 means senses an impedance of the cornea.

1        78. The apparatus of claim 73, wherein said sensing  
2 means senses an impedance of the cornea.

1        79. A method for performing a medical procedure on a  
2 cornea, comprising:

3        placing a probe in contact with a cornea;  
4        delivering a radio frequency energy to the cornea  
5 through the probe; and,  
6        sensing a change in a physiology of the cornea while  
7 the radio frequency energy is delivered to the cornea.

1        80. The method of claim 79, wherein a current  
2 delivered to the cornea is sensed while the radio frequency  
3 energy is delivered to the cornea.

1        81. The method of claim 79, wherein a voltage  
2 delivered to the cornea is sensed while the radio frequency  
3 energy is delivered to the cornea.

1        82. The method of claim 79, wherein an impedance of  
2 the cornea is sensed while the radio frequency energy is  
3 delivered to the cornea.

1        83. The method of claim 79, wherein a temperature of  
2 the cornea is sensed while the radio frequency energy is  
3 delivered to the cornea.

1        84. The method of claim 79, wherein a moisture of the  
2 cornea is sensed while the radio frequency energy is  
3 delivered to the cornea.

1        85. An apparatus that provides a non-thermal energy to  
2 a cornea through a probe to perform a medical procedure  
3 that denatures collagen tissue and reshapes the cornea,  
4 comprising:

5        an energy circuit that delivers a non-thermal energy to  
6 the cornea through the probe; and,

7       a regulator circuit that controls the non-thermal  
8    energy delivered to the cornea during the medical  
9    procedure.

1       86. The apparatus of claim 85, wherein the non-thermal  
2    energy is in a microwave frequency range.

1       87. The apparatus of claim 85, wherein the non-thermal  
2    energy is in an ultrasonic frequency range.

1       88. The apparatus of claim 85, wherein the non-thermal  
2    energy is light.

1       89. The apparatus of claim 85, wherein the non-thermal  
2    energy is direct current.

1       90. The apparatus of claim 85, further comprising a  
2    sensing circuit that senses a change in a physiology of the  
3    cornea during the medical procedure and provides a feedback  
4    to said regulator circuit.

1       91. The apparatus of claim 90, wherein said sensing  
2    circuit senses a current delivered to the cornea.

1        92. The apparatus of claim 90, wherein said sensing  
2 circuit senses a voltage delivered to the cornea.

1        93. The apparatus of claim 90, wherein said sensing  
2 circuit senses a temperature of the cornea.

1        94. The apparatus of claim 90, wherein said sensing  
2 circuit senses an impedance of the cornea.

1        95. The apparatus of claim 90, wherein said sensing  
2 circuit senses an optical characteristic of the cornea.

1        96. The apparatus of claim 85, wherein said regulator  
2 circuit controls the delivery of the non-thermal energy  
3 about a set-point.

1        97. The apparatus of claim 85, wherein said regulator  
2 circuit controls the delivery of the non-thermal energy  
3 about a set-curve.

1        98. The apparatus of claim 90, wherein said regulator  
2 circuit determines a profile of a physiological parameter

3 and regulates the non-thermal energy delivered to the  
4 cornea in accordance with the profile.

1 99. The apparatus of claim 98, wherein said regulator  
2 circuit decreases the non-thermal energy if the profile  
3 displays changes indicative of necrotic collagen structural  
4 modification beyond a threshold level during the medical  
5 procedure.

1 100. The apparatus of claim 98, wherein said regulator  
2 circuit terminates delivery of the non-thermal energy if  
3 the profile exceeds a threshold level during the medical  
4 procedure.

1 101. The apparatus of claim 98, wherein said regulator  
2 circuit terminates delivery of the non-thermal energy if  
3 the profile includes a slope that exceeds a threshold level  
4 during the medical procedure.

1 102. The apparatus of claim 85, wherein said regulator  
2 circuit modulates a duration of the delivery of the non-  
3 thermal energy.

1       103. The apparatus of claim 85, wherein said regulator  
2   circuit modulates a level of the non-thermal energy.

1       104. An apparatus that provides a non-thermal energy to  
2   a cornea through a probe to perform a medical procedure  
3   that denatures collagen tissue and reshapes the cornea,  
4   comprising:

5       an energy circuit that delivers a non-thermal energy to  
6   the cornea through the probe; and,

7       regulator circuit means for controlling the non-thermal  
8   energy delivered to cornea during the medical procedure.

1       105. The apparatus of claim 104, wherein the non-  
2   thermal energy is in a microwave frequency range.

1       106. The apparatus of claim 104, wherein the non-  
2   thermal energy is in an ultrasonic frequency range.

1       107. The apparatus of claim 104, wherein the non-  
2   thermal energy is light.

1       108. The apparatus of claim 104, wherein the non-  
2    thermal energy is direct current.

1       109. The apparatus of claim 104, further comprising  
2    sensing circuit means for sensing a change in a physiology  
3    of the cornea during the medical procedure and providing a  
4    feedback to said regulator circuit.

1       110. The apparatus of claim 109, wherein said sensing  
2    circuit means senses a current delivered to the cornea.

1       111. The apparatus of claim 109, wherein said sensing  
2    circuit means senses a voltage delivered to the cornea.

1       112. The apparatus of claim 109, wherein said sensing  
2    circuit means senses a temperature of the cornea.

1       113. The apparatus of claim 109, wherein said sensing  
2    circuit means senses an impedance of the cornea.

1       114. The apparatus of claim 109, wherein said sensing  
2       circuit means senses an optical characteristic of the  
3       cornea.

1       115. The apparatus of claim 104, wherein said regulator  
2       circuit means controls the delivery of the non-thermal  
3       energy about a set-point.

1       116. The apparatus of claim 104, wherein said regulator  
2       circuit means controls the delivery of the non-thermal  
3       energy about a set-curve.

1       117. The apparatus of claim 109, wherein said regulator  
2       circuit means determines a profile of a physiological  
3       parameter and regulates the non-thermal energy delivered to  
4       the cornea in accordance with the profile.

1       118. The apparatus of claim 117, wherein said regulator  
2       circuit means decreases the non-thermal energy if the  
3       profile displays changes indicative of necrotic collagen  
4       structural modification beyond a threshold level during the  
5       medical procedure.

1       119. The apparatus of claim 114, wherein said regulator  
2   circuit means terminates delivery of the non-thermal energy  
3   if the profile exceeds a threshold level during the medical  
4   procedure.

1       120. The apparatus of claim 114, wherein said regulator  
2   circuit means terminates delivery of the non-thermal energy  
3   if the profile includes a slope that exceeds a threshold  
4   level during the medical procedure.

1       121. The apparatus of claim 104, wherein said regulator  
2   circuit means modulates a duration of the delivery of the  
3   non-thermal energy.

1       122. The apparatus of claim 104, wherein said regulator  
2   circuit modulates a level of the non-thermal energy.

1       123. A method for performing a medical procedure on a  
2   cornea, comprising:  
3       contacting a cornea with a probe;

4       delivering a non-thermal energy to the cornea through  
5   the probe to denature collagen tissue and reshape the  
6   cornea; and,

7       regulating the non-thermal energy delivered to cornea  
8   during the medical procedure.

1       124. The method of claim 123, wherein the non-thermal  
2   energy is in a microwave frequency range.

1       125. The method of claim 123, wherein the non-thermal  
2   energy is in an ultrasonic frequency range.

1       126. The method of claim 123, wherein the non-thermal  
2   energy is light.

1       127. The method of claim 123, wherein the non-thermal  
2   energy is direct current.

1       128. The method of claim 123, further comprising  
2   sensing a change in a physiology of the cornea during the  
3   medical procedure and regulating the non-thermal energy  
4   delivered to the cornea as a function of the feedback.

1       129. The method of claim 128, wherein a current  
2 delivered to the cornea is sensed during the medical  
3 procedure.

1       130. The method of claim 128, wherein a voltage  
2 delivered to the cornea is sensed during the medical  
3 procedure.

1       131. The method of claim 128, wherein a temperature of  
2 the cornea is sensed during the medical procedure.

1       132. The method of claim 128, wherein an impedance of  
2 the cornea is sensed during the medical procedure.

1       133. The method of claim 128, wherein an optical  
2 characteristic of the cornea is sensed during the medical  
3 procedure.

1       134. The method of claim 123, wherein the non-thermal  
2 energy is regulated about a set-point.

1       135. The method of claim 123, wherein the non-thermal  
2    energy is regulated about a set-curve.

1       136. The method of claim 128, wherein a profile of a  
2    physiological parameter is determined and the non-thermal  
3    energy delivered to the cornea is regulated in accordance  
4    with the profile.

1       137. The method of claim 136, wherein regulating  
2    includes decreasing the non-thermal energy if the profile  
3    displays changes indicative of necrotic collagen structural  
4    modification beyond a threshold level during the medical  
5    procedure.

1       138. The method of claim 136, wherein regulating  
2    includes terminating delivery of the non-thermal energy if  
3    the profile exceeds a threshold level during the medical  
4    procedure.

1       139. The method of claim 136, wherein regulating  
2    includes terminating delivery of the non-thermal energy if

3 the profile includes a slope that exceeds a threshold level  
4 during the medical procedure.

1 140. The method of claim 123, wherein regulating  
2 includes modulating a duration of the delivery of the non-  
3 thermal energy.

1 141. The method of claim 123, wherein regulating  
2 includes modulating a level of the non-thermal energy.

1 142. An apparatus that provides a non-thermal energy to  
2 a cornea through a probe to perform a medical procedure  
3 that denatures collagen tissue and reshapes the cornea,  
4 comprising:

5 a energy circuit that delivers a non-thermal energy to  
6 the cornea through the probe; and,

7 a sensing circuit that senses a change in a physiology  
8 of the cornea while said energy circuit delivers the non-  
9 thermal energy to the cornea.

1 143. The apparatus of claim 142, wherein the non-  
2 thermal energy is in a microwave frequency range.

1       144. The apparatus of claim 142, wherein the non-  
2       thermal energy is in an ultrasonic frequency range.

1       145. The apparatus of claim 142, wherein the non-  
2       thermal energy is light.

1       146. The apparatus of claim 142, wherein the non-  
2       thermal energy is direct current.

1       147. The apparatus of claim 142, wherein said sensing  
2       circuit senses a current delivered to the cornea.

1       148. The apparatus of claim 142, wherein said sensing  
2       circuit senses a voltage delivered to the cornea.

1       149. The apparatus of claim 142, wherein said sensing  
2       circuit senses a temperature of the cornea.

1       150. The apparatus of claim 142, wherein said sensing  
2       circuit senses an impedance of the cornea.

1       151. The apparatus of claim 142, wherein said sensing  
2       circuit senses an optical characteristic of the cornea.

1       152. An apparatus that provides a non-thermal energy to  
2   a cornea through a probe to perform a medical procedure to  
3   denature collagen tissue and reshape the cornea,  
4   comprising:

5       an energy circuit that delivers a non-thermal energy to  
6   the cornea through the probe; and,  
7       sensing means for sensing a change in a physiology of  
8   the cornea while said energy circuit delivers the non-  
9   thermal energy delivered to the cornea.

1       153. The apparatus of claim 152, wherein the non-  
2   thermal energy is in a microwave frequency range.

1       154. The apparatus of claim 152, wherein the non-  
2   thermal energy is in an ultrasonic frequency range.

1       155. The apparatus of claim 152, wherein the non-  
2   thermal energy is light.

1       156. The apparatus of claim 152, wherein the non-  
2   thermal energy is direct current.

1       157. The apparatus of claim 152, wherein said sensing  
2 means senses a current delivered to the cornea.

1       158. The apparatus of claim 152, wherein said sensing  
2 means senses a voltage delivered to the cornea.

1       159. The apparatus of claim 152, wherein said sensing  
2 means senses a temperature of the cornea.

1       160. The apparatus of claim 152, wherein said sensing  
2 means senses an impedance of the cornea.

1       161. The apparatus of claim 152, wherein said sensing  
2 means senses an optical characteristic of the cornea.

1       162. A method for performing a medical procedure on a  
2 cornea, comprising:

3       contacting a cornea with a probe;

4       delivering a non-thermal energy to the cornea through  
5 the probe; and,

6       sensing a change in a physiology of the cornea while  
7 the non-thermal energy is delivered to the cornea.

1       163. The method of claim 162, wherein the non-thermal  
2 energy is in a microwave frequency range.

1       164. The method of claim 162, wherein the non-thermal  
2 energy is in an ultrasonic frequency range.

1       165. The method of claim 162, wherein the non-thermal  
2 energy is light.

1       166. The method of claim 162, wherein the non-thermal  
2 energy is direct current.

1       167. The method of claim 162, wherein a current  
2 delivered to the cornea is sensed while the non-thermal  
3 energy is delivered to the cornea.

1       168. The method of claim 162, wherein a voltage  
2 delivered to the cornea is sensed while the non-thermal  
3 energy is delivered to the cornea.

1        169. The method of claim 162, wherein a temperature of  
2        the cornea is sensed while the non-thermal energy is  
3        delivered to the cornea.

1        170. The method of claim 162, wherein an optical  
2        characteristic of the cornea is sensed while the non-  
3        thermal energy is delivered to the cornea.